
Advances and Opportunities for Heavy-Ion Fusion Targets

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General Atomics



VNL PAC

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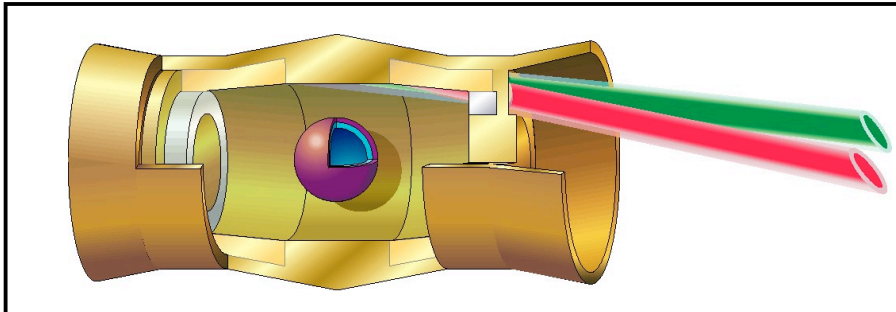
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HIF/IFE needs to be ready to take advantage of NIF ignition experiments in 2010

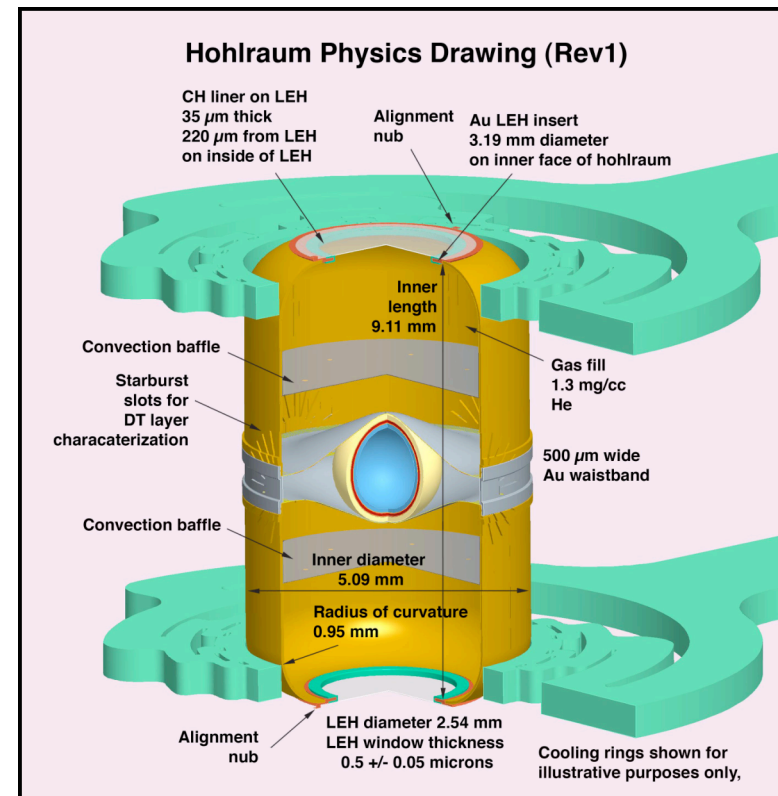


- Because HIF and ZIFE use indirect drive targets, much of the physics validation will happen as part of the NIC
 - X-ray driven capsule physics
 - Rayleigh-Taylor instability growth
 - Radiation transport
 - Symmetry

Heavy Ion Distributed Radiator Target



NIF “Design 1” Target

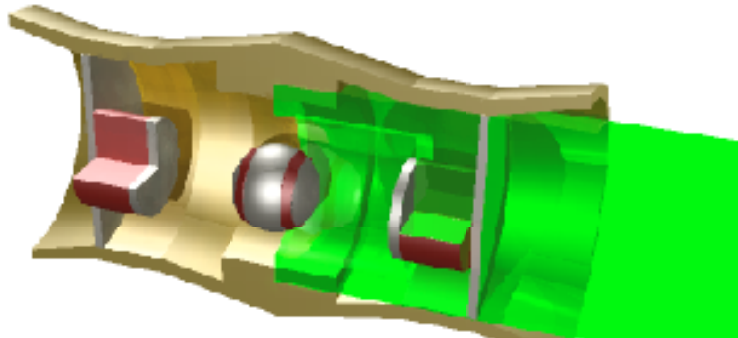


Ignition on NIF is essential to the success of IFE

In addition to NIF, we should look at other NNSA facilities for HIF/IFE relevant exp'ts

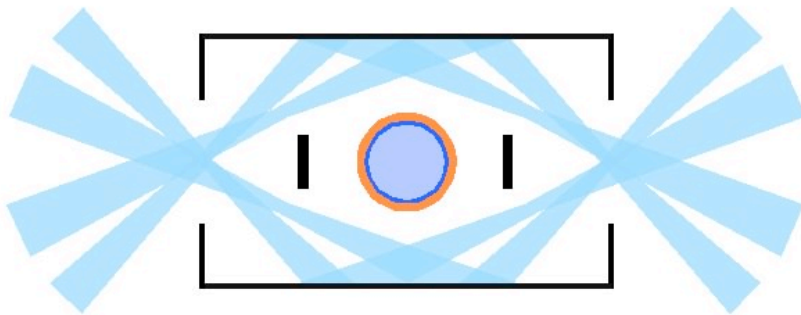


HI Hybrid target



Shield blocks hotspot due to beams

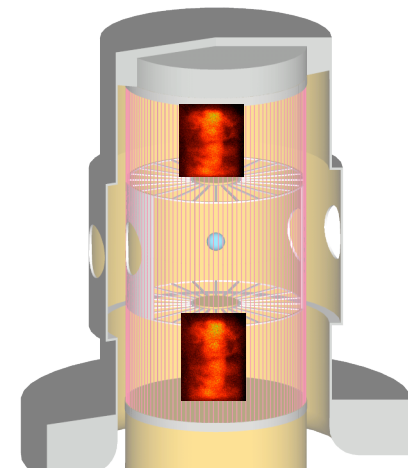
NIF LEH-shield target



Shield blocks cold LEH

Our first HIF target expt were fielded on Z

Double Z-pinch target



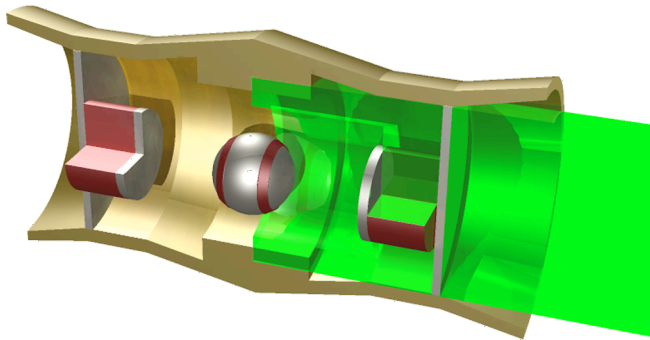
Shield blocks hot z-pinch

Hybrid target allows a large beam spot which is easier for the accelerator/final focus



 **GENERAL ATOMICS**

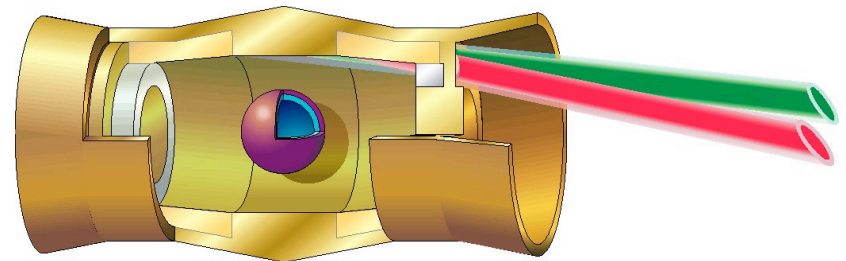
Hybrid target



3.8 x 5.4 mm

Gain ~ 60 from 6.7 MJ

Distributed Radiator target



1.8 x 4.15 mm

Gain ~ 70 from 5.9 MJ

The hybrid target uses new methods for controlling symmetry that need to be tested

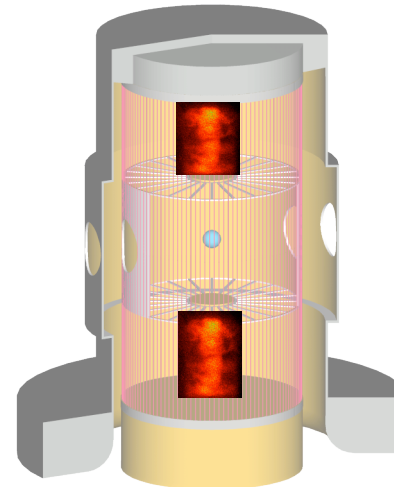


- The hybrid target uses internal shields to control symmetry
 - A shine shield controls P_2
 - A shim corrects the P_4
- The hybrid target and the Z double-pinch target use similar methods for controlling symmetry
 - This results in a natural area for collaboration

HI hybrid target



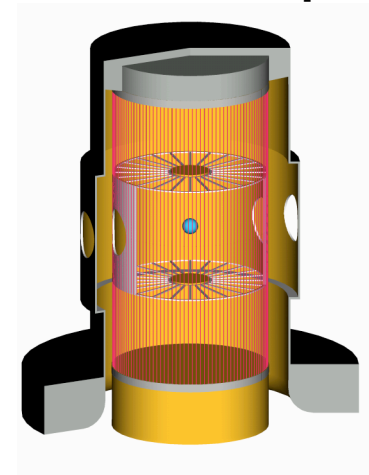
Z double-pinch target



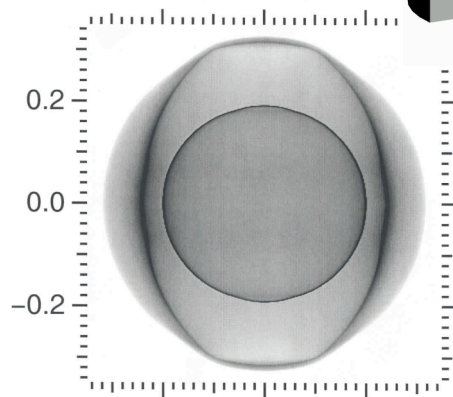
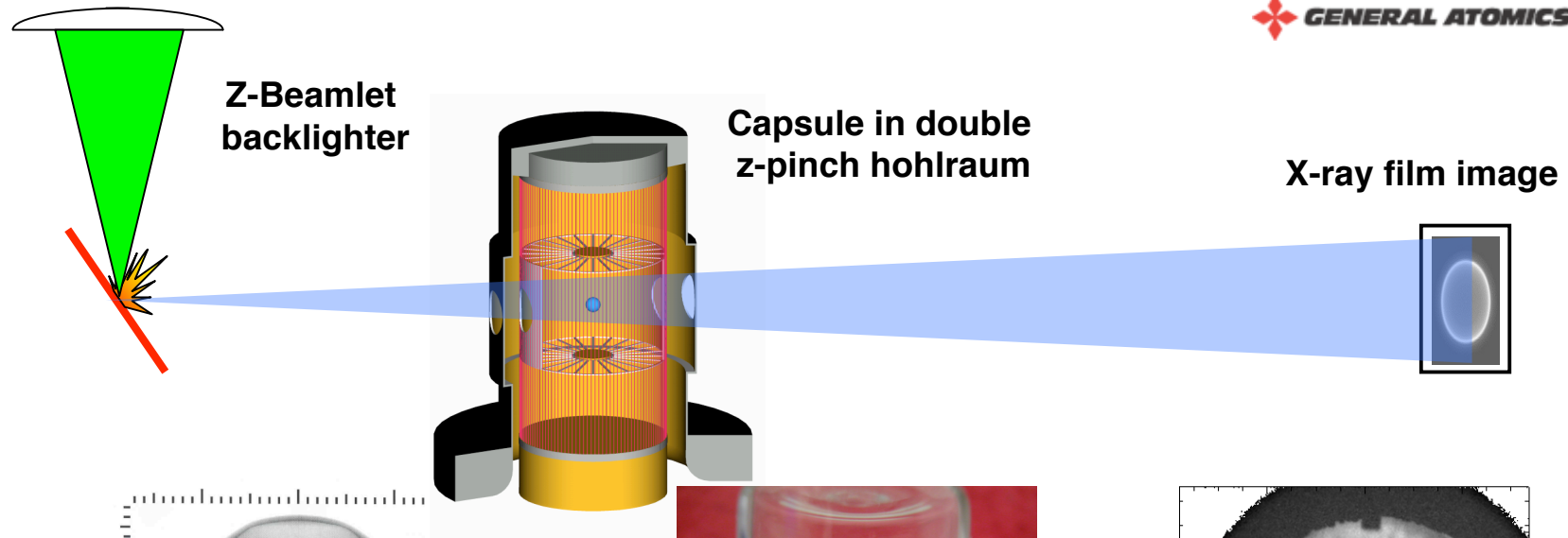
Shims are a technique for improving early time symmetry in IFE/ICF capsules



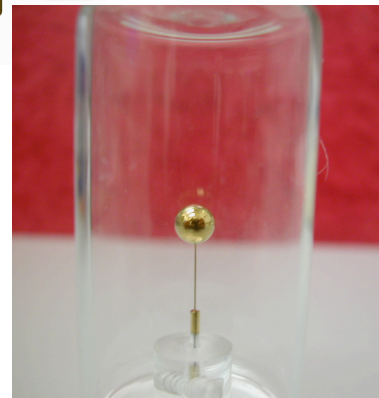
- The shim is a thin layer of material that is placed on or near the capsule surface to block the capsule from excess radiation
- Because radiation is smoothed, it is easiest to remove the asymmetry very close to the capsule surface
 - asymmetry is small -> does not take much material to remove it
- Shim can only correct early time asymmetries
 - Later, shim material burns through and is pushed away by ablator
 - Symmetry may improve late in pulse because hohlraum heats up and capsule shrinks
- Shim may excite short wavelength perturbations



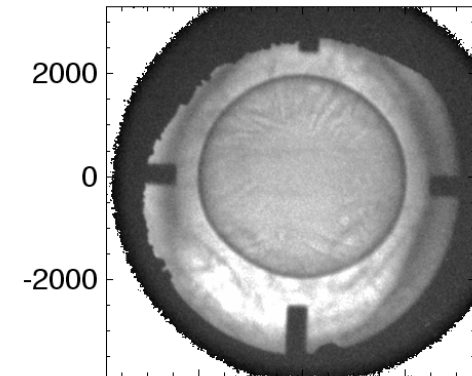
We have done experiments to test shims in a double z-pinch hohlraum on Z at SNL



LLNL
Theory and Design

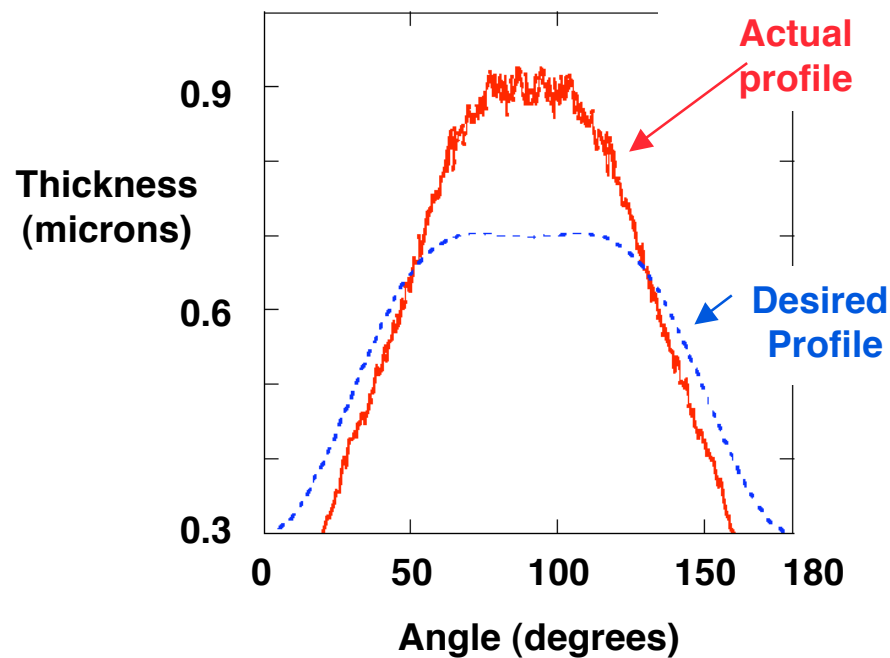


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Capsule Fabrication

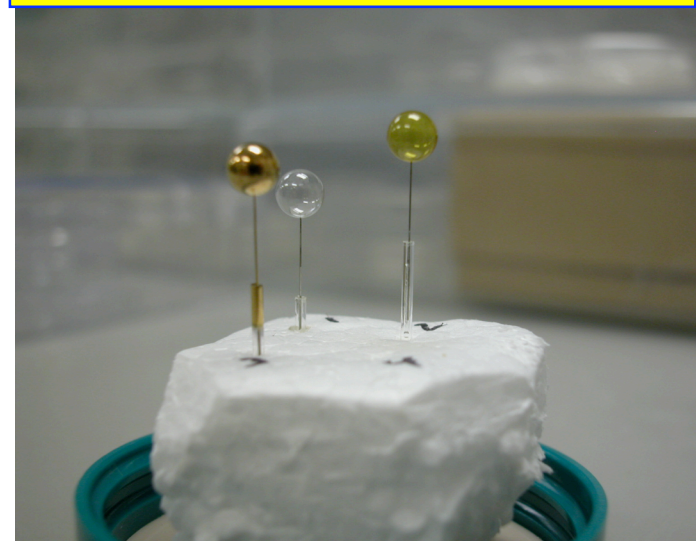


SNL
Experiment and
Hohlraum Fabrication

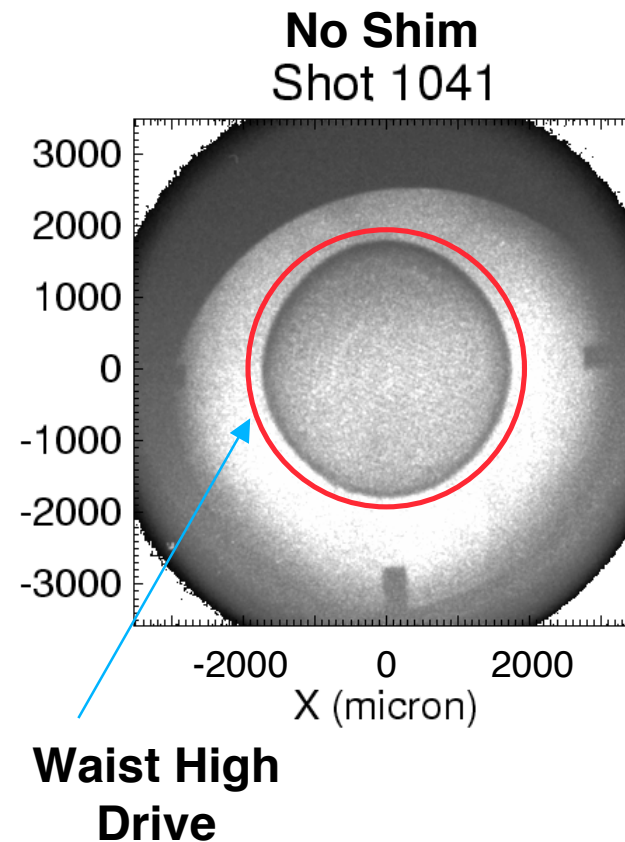
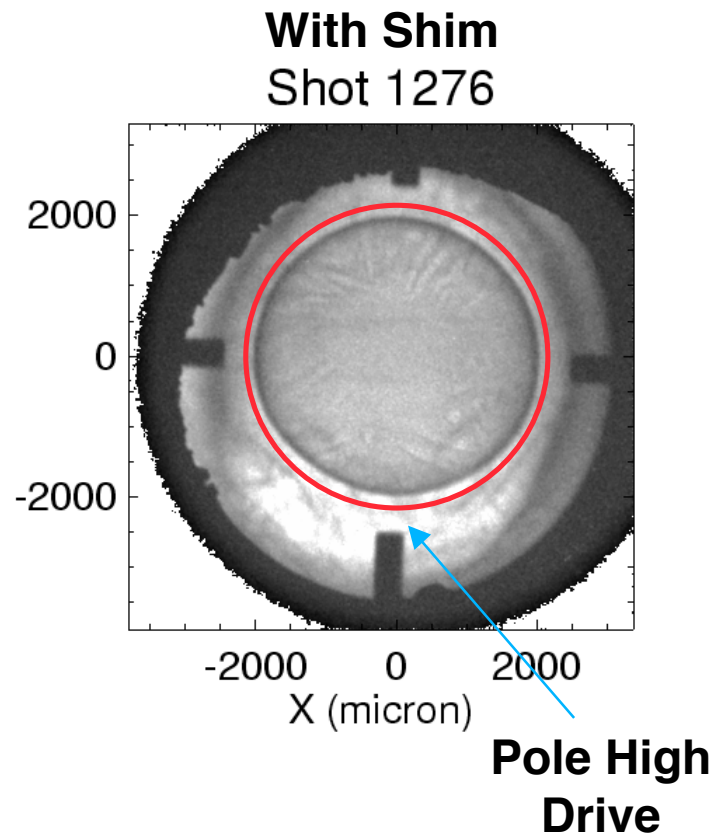
The gold shim layer was fabricated by rotating a capsule under a coater with a mask



Photograph of capsule mandrel, Ge-doped CH shell, and coated target



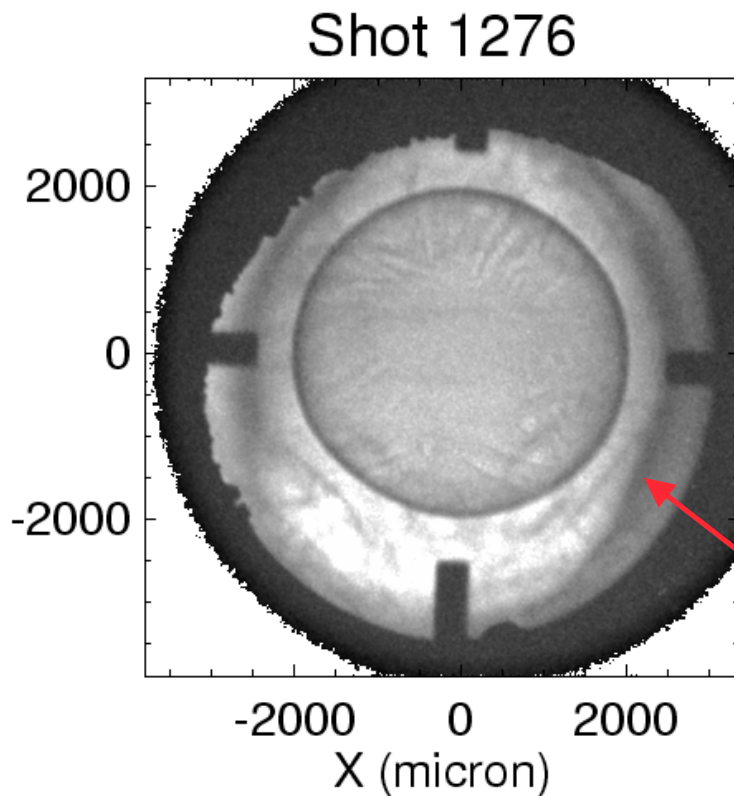
The first experiments showed that we reversed a P_2 from waist high to pole high



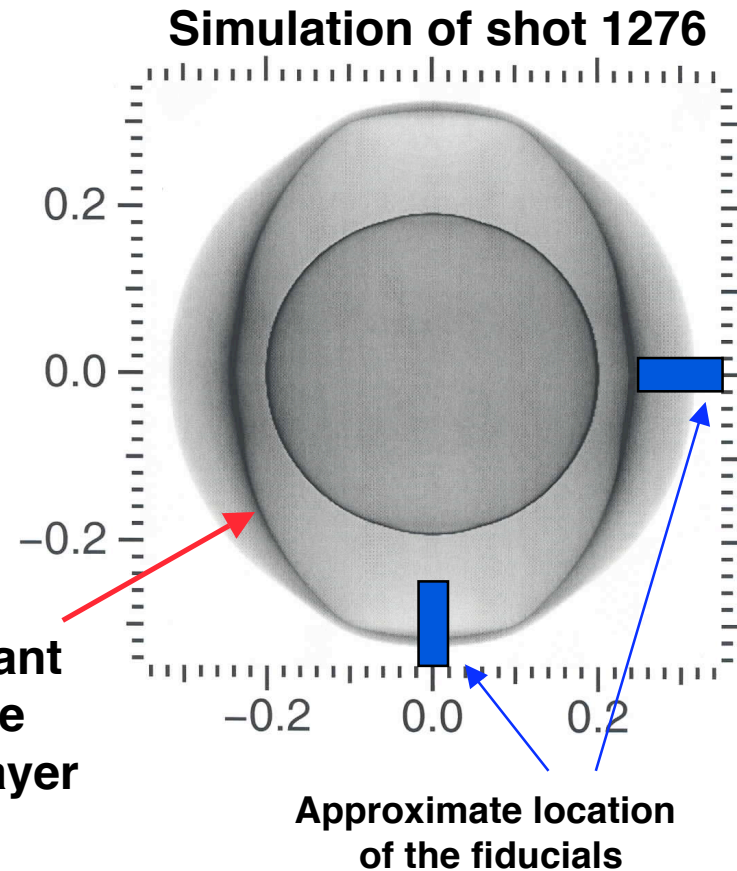
Since the image was early in time, we see evidence of the shim layer in the radiograph



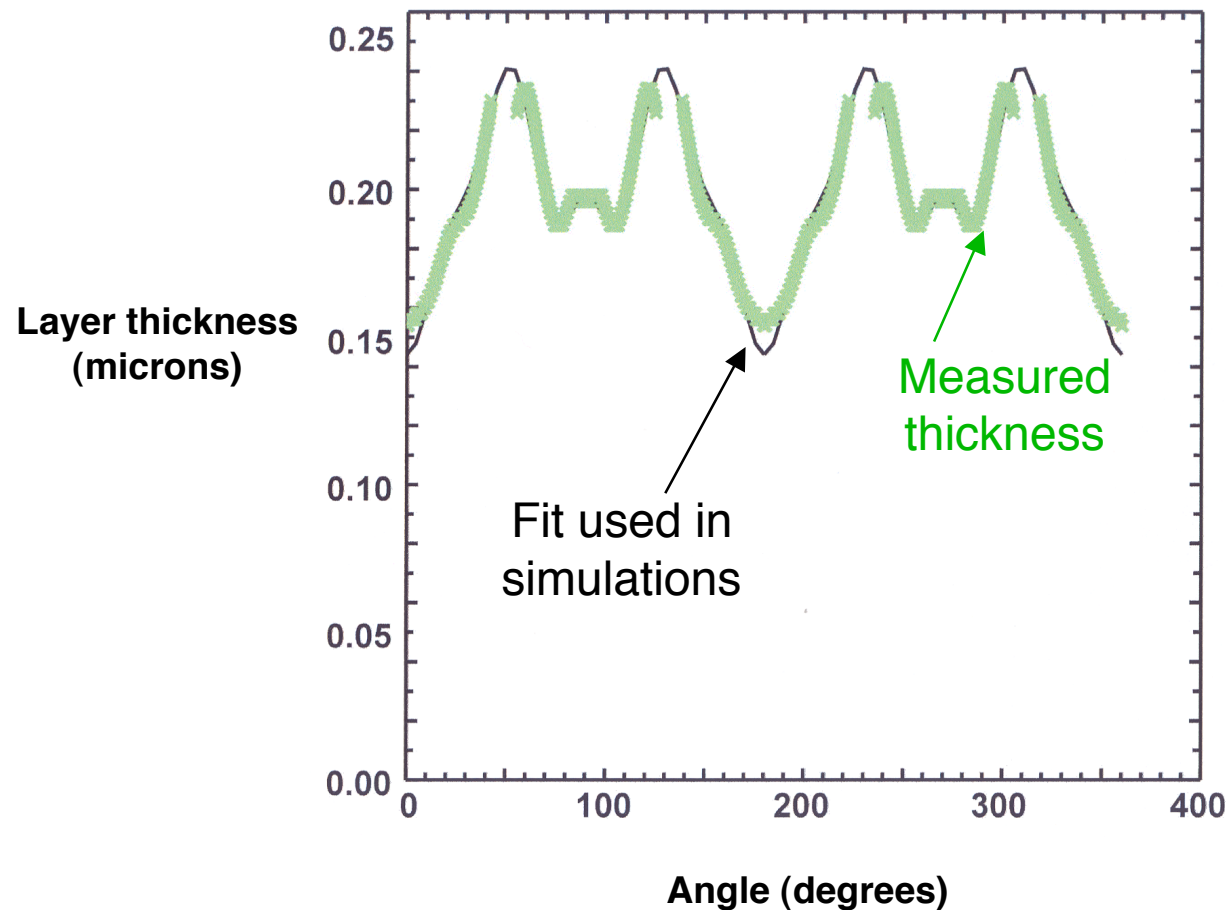
 **GENERAL ATOMICS**



Remnant
of the
shim layer



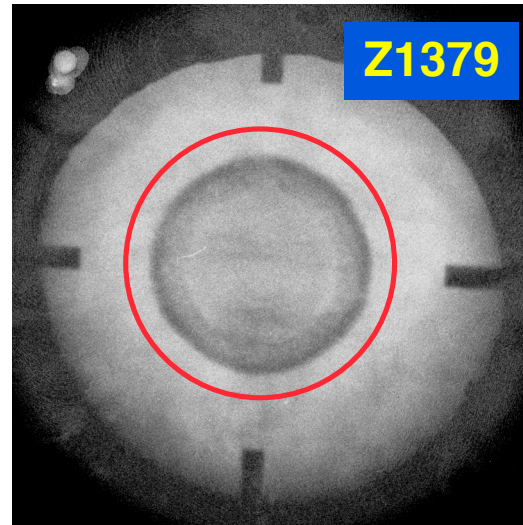
**Second set of expts attempted to remove a P₄:
a gold shim layer was applied to the capsules**



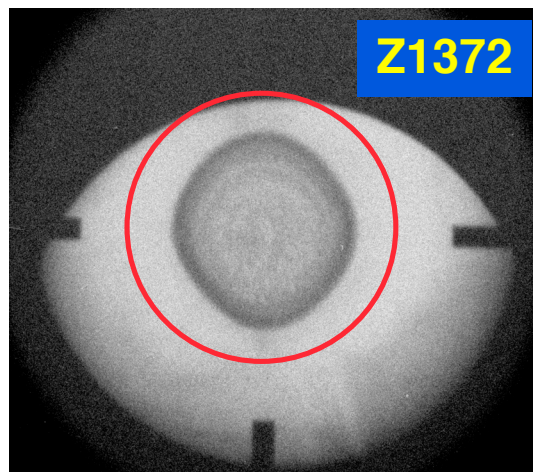
Experiments with the shim show a rounder implosion



With Shim



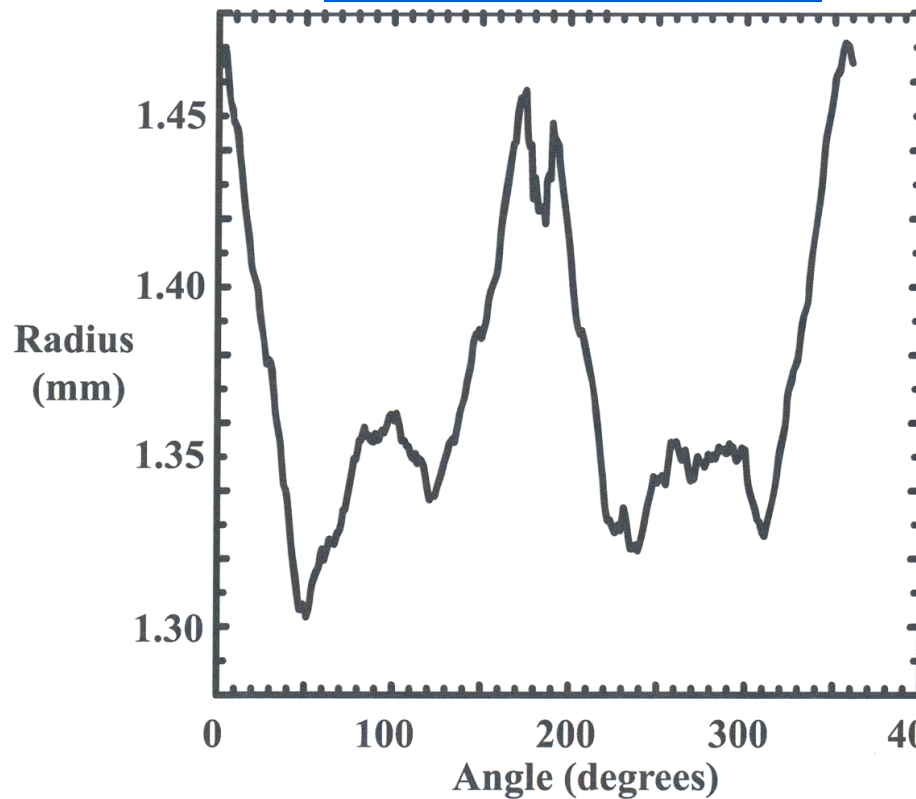
No Shim



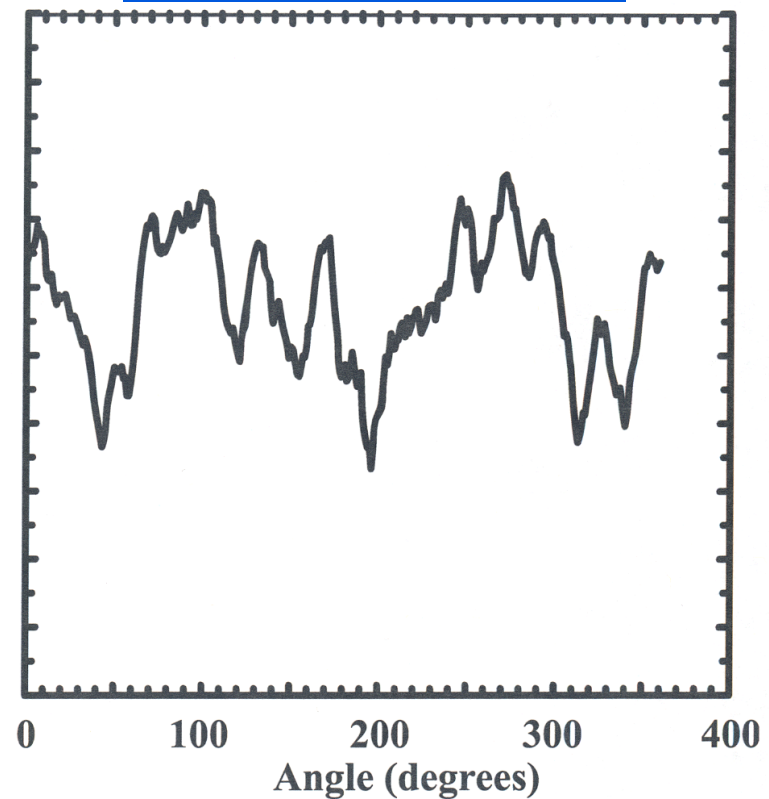
Lineouts of the experimental images confirm a rounder implosion



Shot Z1373: No Shim



Shot 1379: With Shim

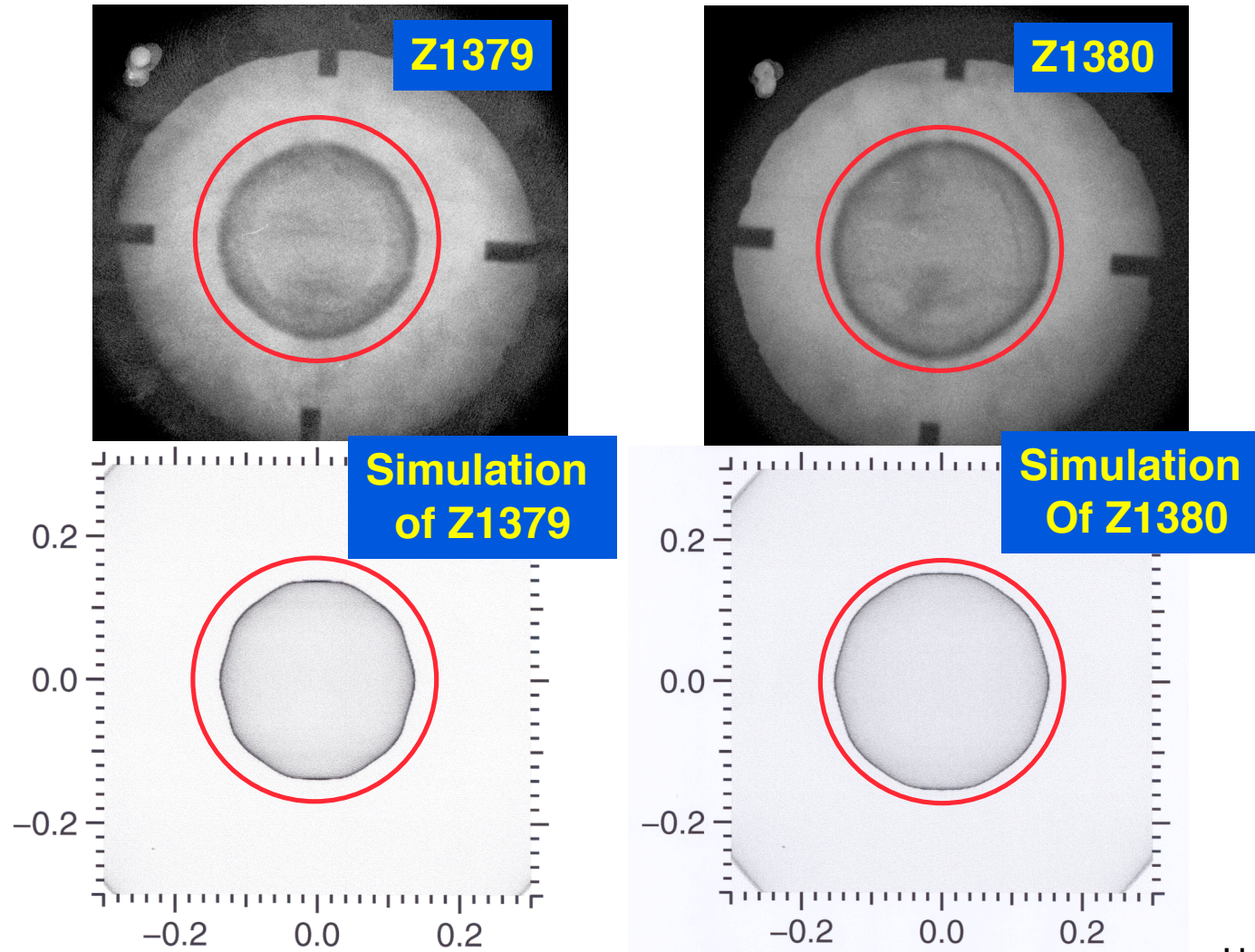


Excursions are reduced by a factor of 2

Simulated radiographs also show a rounder implosion



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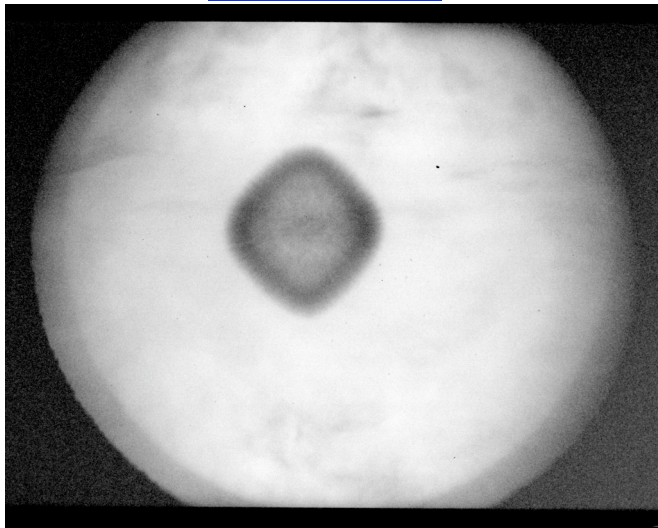
Identifying Marker. 14

Final set of experiments used a very thick layer to reverse a P_4 asymmetry

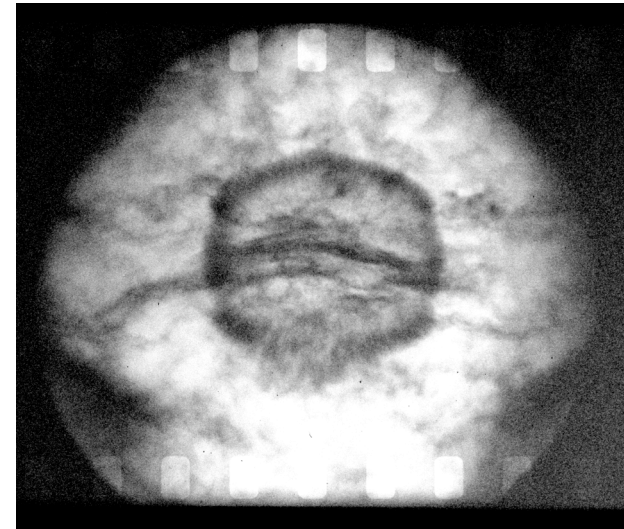


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No Shim



Thick Shim



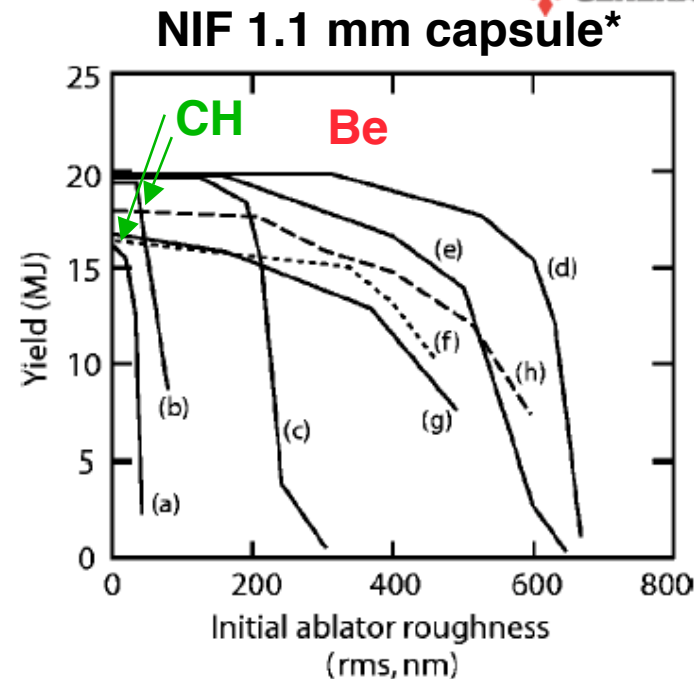
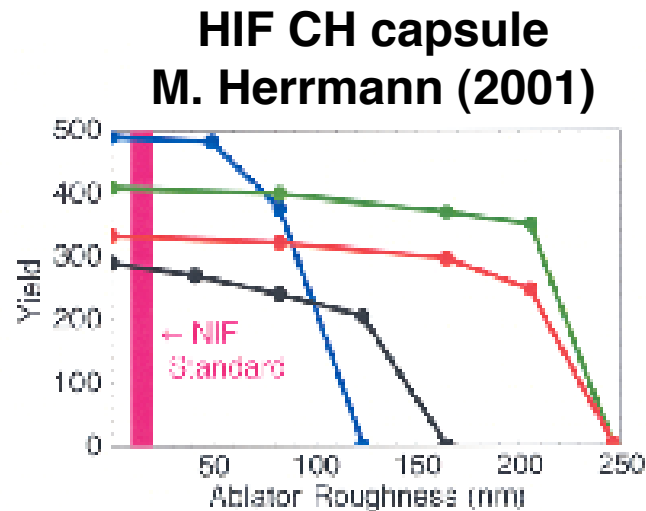
Layer was very thick (to exaggerate effect)--
net result is layer effected radiograph

To proceed with this technique, we need to understand the effect of the blow-off layer on the hohlraum, and then move on to multi-shock systems and higher convergence ratio

Techniques for optimizing the HIF capsule were further developed and used for NIF



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- We used to argue that the HIF capsule could tolerate 10x “NIF standard” which would allow us to mass produce targets
 - Better NIF designs now tolerate 30x “NIF standard”!
- We need to revisit HIF capsule optimization and fabrication
 - Would fill tubes allow Be capsules for HIF?

*S. Haan, Phys Plasmas, 12,056316 (2005).

We should look for opportunities to leverage off NNSA programs/facilities



- **NIF shots are likely to be in highly competitive**
 - **Should think about validating ideas first on other facilities**
- **ZR with Beamlet (SNL)**
 - **Z is being refurbished; higher Tr (~ 95 eV rather than 70 eV)**
- **Omega/Omega EP (U of Rochester)**
 - **Omega experiments routinely at high (~ 20) convergence ratio with shaped pulse**
 - **Continue experiments on shims**
 - **Could also test IFE-relevant hohlraum materials**
- **Short pulse laser facilities (Titan (aka JanUSP), L'Oasis, RAL, ILE Osaka, Omega EP)**
 - **Fast ignition studies**
 - **Produce ion/electron beams to study HIF radiator physics**

Once we have robust ignition on NIF, we can use it to explore alternatives for IFE

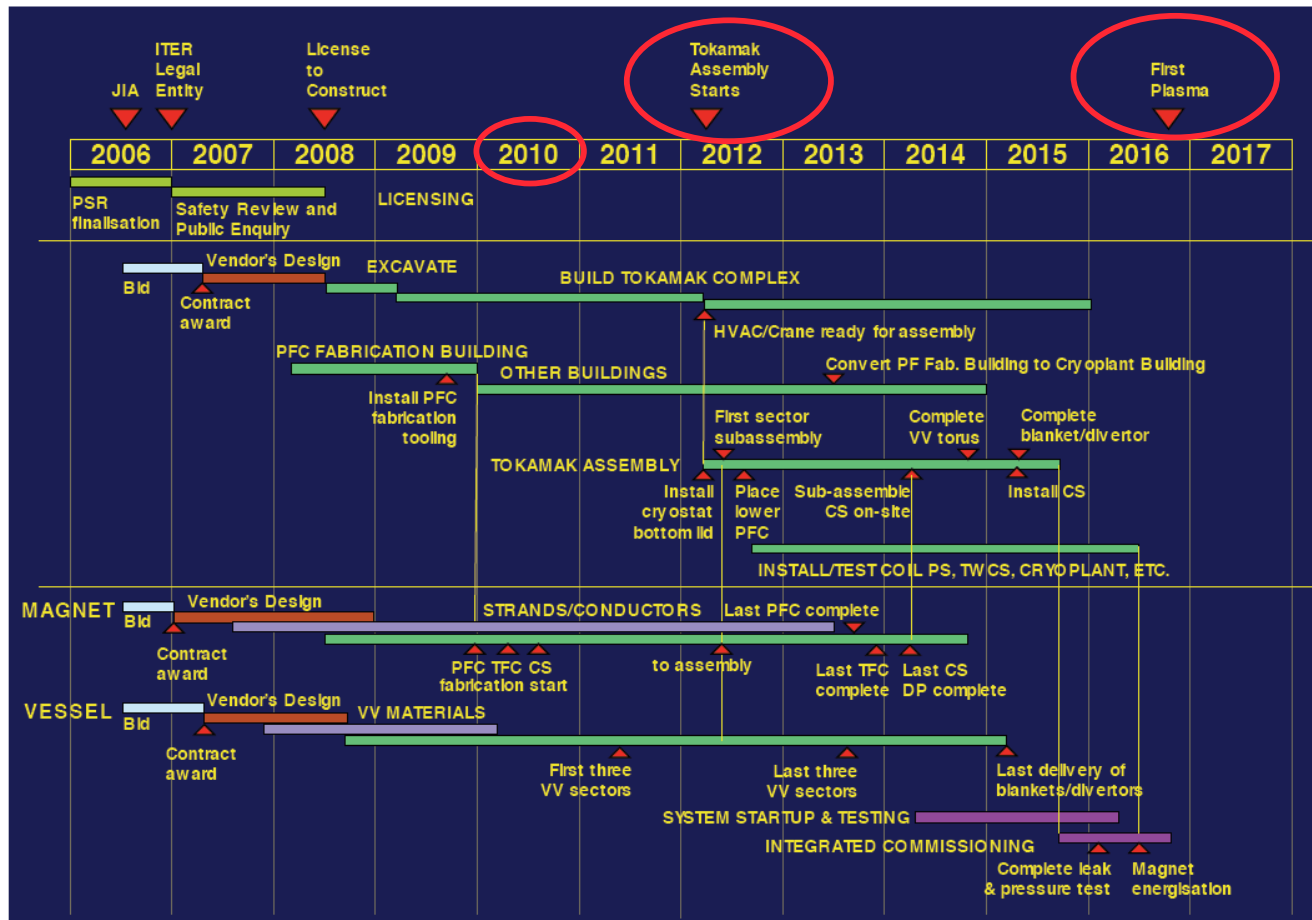


- Ablator materials (Be vs CH)
- Allowable ablator roughness
- Fill tube size
- Capsule tent thickness
- DT ice roughness
- Hohlraum materials

Many of these can be studied on smaller facilities before ignition

**HIF/IFE capsules tend to be ~2-2.5x larger than NIF
We will need to use simulations to extrapolate NIF results to IFE**

We will begin NIF ignition experiments well before ITER tokamak assembly begins



Source:
www.iter.org

We should be ready to take advantage of ignition on NIF with an attractive HIF driver/target/chamber combination